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# REPORT NO. 98-06

# EUROPALLET TESTING AND EVALUATION STANAG 2828 AND MIL-STD-1660 TESTS

Prepared for:
U.S. Army Armament Research, Development and Engineering Center
ATTN: AMSTA-AR-ESK
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**VALIDATION ENGINEERING DIVISION**
**SAVANNA, ILLINOIS 61074-9639**

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The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct STANAG 2828 and MIL-STD-1660 tests on the Europallet. Test results showed that the Europallet met the test requirements of STANAG 2828 at a test weight of 2,208 pounds, but failed to meet test requirements of MIL-STD-1660 at a test weight of 4,018 pounds. This report contains details of the tests conducted.

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## ABSTRACT

The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC), to conduct STANAG 2828 and MIL-STD-1660 tests on Europallet. Test results showed that the Europallet met the test requirements of STANAG 2828 at a test weight of 2,208 pounds but failed to meet the test requirements of MIL-STD-1660 at a test weight of 4,018 pounds. This report contains details of tests conducted.

U.S. ARMY DEFENSE AMMUNITION CENTER
VALIDATION ENGINEERING DIVISION
SAVANNA, IL 61074-9639

REPORT NO. 98-06

# EUROPALLET TESTING AND EVALUATION
# STANANG 2828 AND MIL-STD-1660 TESTS

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PART 1

# INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the U.S. Army Armament Research, Development and Engineering Center (ARDEC) to conduct STANAG 2828 and MIL-STD-1660 tests on 32- by 48-inch wooden Europallets.

B. AUTHORITY. These tests were conducted IAW mission responsibilities delegated by the U.S. Army Armament, Munitions and Chemical Command (AMCCOM), Rock Island, IL.

C. OBJECTIVE. The objective of these tests was to determine whether the wooden Europallets were capable of meeting STANAG 2828 and MIL-STD-1660, Design Criteria for Ammunition Unit Loads requirements.

D. CONCLUSION. The wooden Europallets met STANAG 2828 requirements at a test weight of 2,208 pounds but failed MIL-STD-1660 requirements at a test weight of 4,000 pounds.

PART 2

JANUARY 1998

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PART 3

## TEST PROCEDURES

### MIL-STD-1660

The test procedures outlined in this section were extracted from MIL-STD-1660, Design Criteria for Ammunition Unit Loads, 8 April 1977. This standard identifies nine steps that a unitized load must undergo if it is to be considered acceptable. The four tests that were conducted on the test pallets are summarized below.

A. STACKING TEST. The unit load was loaded to simulate a stack of identical unit loads stacked 16 feet high, for a period of one hour. This stacking load was simulated by subjecting the unit load to a compression weight equal to an equivalent 16-foot stacking height. The compression load was calculated in the following manner. The unit load weight was divided by the unit load height in inches and multiplied by 192. The resulting number was the equivalent compressive force of a 16-foot-high load.

B. REPETITIVE SHOCK TEST. The repetitive shock test was conducted IAW Method 5019, Federal Standard 101. The test procedure is as follows: The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles per second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch-thick feeler gage momentarily slid freely between every point on the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved 1 +/- 0.1 Gs. Midway into the testing period, the specimen was rotated 90 degrees and the test continued for the duration. Unless failure occured,

the total time of vibration was two hours if the specimen was tested in one position and three hours for more than one position.

C. EDGEWISE ROTATIONAL DROP TEST. This test was conducted using the procedures of Method 5008, Federal Standard 101. The procedure for the edgewise rotational drop test is as follows: The specimen was placed on its skids with one end of the pallet supported on a beam 4-1/2 inches high. The height of the beam was increased if necessary to ensure that there was no support for the skids between the ends of the pallet when dropping took place, but was not high enough to cause the pallet to slide on the supports when the dropped end was raised for the drops. The unsupported end of the pallet was then raised and allowed to fall freely to the concrete, pavement, or similar underlying surface from a prescribed height. Unless otherwise specified, the height of drop for level A protection conforms to the following tabulation:

| GROSS WEIGHT (WITHIN RANGE LIMITS) (Pounds) | DIMENSIONS OF ANY EDGE, HEIGHT OR WIDTH (WITHIN RANGE LIMITS) (Inches) | HEIGHT OF DROPS ON EDGES | |
|---|---|---|---|
| | | Level A (Inches) | Level B (Inches) |
| 150 - 250 | 60 - 66 | 36 | 27 |
| 250 - 400 | 66 - 72 | 32 | 24 |
| 400 - 600 | 72 - 80 | 28 | 21 |
| 600 - 1000 | 80 - 95 | 24 | 18 |
| 1000 - 1500 | 95 - 114 | 20 | 16 |
| 1500 - 2000 | 114 - 144 | 17 | 14 |
| 2000 - 3000 | Above 145 - No limit | 15 | 12 |
| Above - 3000 | | 12 | 9 |

D. INCLINE-IMPACT TEST. This test was conducted by using the procedure of Method 5023, Incline-Impact Test of Federal Standard 101. The procedure for the incline-impact test is as follows: The specimen was placed on the carriage with the surface or edge which is to be impacted projecting at least 2 inches beyond the front end of the carriage. The carriage was brought to a predetermined position on the incline and released. If it is desired to concentrate the impact on any particular position on the container, a 4- by 4-inch timber was attached to the bumper in the desired position before the test. No part of the timber was struck by the carriage. The position of the container on the carriage and the sequence in which surfaces and edges are subjected to impacts was at the option of the testing activity and depends upon the objective of the tests. This test is to determine satisfactory requirements for a container or pack, and, unless otherwise specified, the specimen was subjected to one impact on each surface that has each dimension less than 9.5 feet. Unless otherwise specified, the velocity at time of impact was 7 feet per second.

## STANAG 2828

The test procedures outlined in this section were extracted from STANAG 2828, MH (edition 4) - Military Pallets, Packages and Containers, 19 December 1995 issued by North Atlantic Treaty Organization. This standard identifies 7 steps that a unitized load must undergo if it is to be considered acceptable. The tests conducted are summarized below.

A. MECHANICAL HANDLING COMPATIBILITY. The unit load was lifted to full lift height with a Military Standard 4,000 pound forklift, transported a distance of 15 meters (50 feet) and lowered. The pallet was rotated clockwise after each test, until all four sides had been tested.

B. SUPERIMPOSED LOAD OR STACKING TEST. The unit load was subjected to a compression weight equal to 4W for a period of one hour, via a pallet base identical to the base of the unit load being tested, to the top of the unit where W is the maximum all-up mass of the unit load being tested. The compression weight was released and after an interval of one hour, was reapplied for one more hour.

C. STABILITY. After completion of the stacking test, the unit load was placed on a level paved surface (floor). A load equivalent to 3W was applied to the unit load via a pallet base of the unit identical to the base of the unit load being tested to the top of the unit load where W is the maximum all-up mass of the unit load being tested with its corresponding sides parallel but offset, by a distance of 0.2H where H is the unit load height from the center of gravity of the unit load under test. The change of inclination to the horizontal of the base of the upper pallet was measured.

D. INCLINE- IMPACT. This test was conducted by using a procedure similar to Method 5023, Incline-Impact Test of Federal Standard 101. The specimen was placed on the carriage with the surface or edge which is to be impacted projecting at least 2 inches beyond the front end of the

carriage. The carriage was brought to a predetermined position on the incline and released. The velocity at the time of impact was 7 feet-per-second. The load was rotated clockwise until all four sides had been tested.

E. LOW FREQUENCY VIBRATION. The test was conducted by using a procedure similar to Method 5019, Federal Standard 101. The test specimen was placed on, but not fastened to, the platform. With the specimen in one position, the platform was vibrated at 1/2-inch amplitude (1-inch double amplitude) starting at a frequency of approximately 3 cycles-per-second. The frequency was steadily increased until the package left the platform. The resonant frequency was achieved when a 1/16-inch feeler gage momentarily slid freely between every point of the specimen in contact with the platform at some instance during the cycle or a platform acceleration achieved 1+0.1 Gs. The total time of vibration was one hour. The test was then repeated for a further hour with the load rotated through 90 degrees.

F. ROLL OVER TEST. The unit load was laid on its side on two timber runners measuring 100- by 100mm (4- by 4-inch), in cross-section placed on a level paved area. The runners were placed parallel to one another and at such a distance apart that one runner supports the pallet edge and the other supports one of the top edges. The unit load was rotated without shock so that each side of the former vertical face was, in turn, placed at the bottom. The test was repeated until all the sides had been tested.

G. STRAP REMOVAL TEST. The unit load was squared up within 51mm (2 inches) of its original shape and positioned on a flat level surface. The strapping was cut and removed.

PART 4

## TEST EQUIPMENT

A. Europallet: STANAG 2828

| | |
|---|---|
| 1. Size: | 32- by 48-inch |
| 2. Pallet Load: | 7.62mm wooden boxes |
| 3. Quantity of Containers: | 40 |
| 4. Weight Loaded: | 2,208 pounds |
| 5. Unit Load Height: | 46-1/2 inches |

B. Europallet: MIL-STD-1660

| | |
|---|---|
| 1. Size: | 32- by 48-inch |
| 2. Pallet Load: | Prototype PA120 40mm boxes |
| 3. Quantity of Containers: | 64 |
| 4. Weight Loaded: | 4,018 pounds |
| 5. Unit Load Height: | 45 inches |

C. Compression Tester.

| | |
|---|---|
| 1. Manufacturer: | Ormond Manufacturing |
| 2. Platform: | 60- by 60-inches |
| 3. Compression Limit: | 50,000 pounds |
| 4. Tension Limit: | 50,000 pounds |

D. Transportation Simulator.

| | |
|---|---|
| 1. Manufacturer: | Gaynes Laboratory |
| 2. Capacity: | 6,000-pound pallet |
| 3. Displacement: | 1/2-inch amplitude |
| 4. Speed: | 50 to 400 rpm |
| 5. Platform: | 5- by 8-foot |

E. Inclined Plane.

| | |
|---|---|
| 1. Manufacturer: | Conbur Incline |
| 2. Type: | Impact Tester |
| 3. Grade: | 10 percent incline |
| 4. Length: | 12-foot |

PART 5

TEST RESULTS

STANAG 2828

TEST OBSERVATIONS. The test pallet was loaded with 40 7.62mm wooden boxes filled with approximately 55 pounds of sand, creating a total unitized load of 2,208 pounds.

A. MECHANICAL HANDLING COMPATIBILITY TEST. The unit load was stable when lifted to a full lift height with a Military Standard 4,000-pound forklift. There was no difficulty in inserting or removing the forklift from the unit load.

B. SUPERIMPOSED LOAD OR STACKING TEST. The settlement in the first hour and the amount it recovers after unloading was measured. The difference in these two values was expressed as a ratio of the first settlement. The settlement in the second hour and the amount of its recovery after having been unloaded for one hour was also measured the difference of the two values was also expressed as a ratio of the second settlement. These two ratios when added together was found to be less than 0.5.

C. STABILITY TEST. The change of inclination of the base of the upper pallet/second unit load to the horizontal was measured at hourly intervals. Three hourly readings were taken. The cumulative value of the readings was not greater than 1 degree 30 minutes. This value was considered satisfactory.

D. INCLINE- IMPACT TEST. The incline-plane was set to allow the pallet to travel 8 feet prior to impacting a stationary wall. The pallet was rotated clockwise after each impact, until all four sides had been tested. During the test, the outside top-deck board measuring

1-1/4- by 37-1/2-inches broke off. No distortion due to elongation of the length of the diagonal of the load was noticed.

E. LOW FREQUENCY TEST. The duration of the test was 60 minutes for each orientation of the test sample. In order to achieve the required clearance between the test sample and the transportation simulator bed, the equipment was operated at 280 rpm for the lateral orientation and 276 rpm for the longitudinal orientation. The residual tension in the strapping was measured; it was found to be greater than half the original tension. No physical damage was noticed on the test sample or spillage of its contents.

F. ROLL OVER TEST. During the test, the outside bottom deck board (skid) measuring 1-1/8- by 30-3/4-inches broke off. No part of the palletized load was detached when the whole load was supported in this fashion.

G. STRAP REMOVAL TEST. Following the conclusion of the above tests, the unit load was inspected to ascertain that it retained its unity. No package or container toppled from the unit load.

E. END OF TEST INSPECTION. During final inspection, it was noticed that no part of the assembly structure, (the pallet, structural or protective members, strapping, etc.) had failed or permitted individual parts of the unit load assembly to become unattached or separated to such a degree that safe transport, handling, and storage of the unit load was prohibited after each stage of testing. It was also observed that no container was damaged beyond usefulness or to the extent that removal of the contents was prohibited. Therefore the assembly structure met the test requirements of STANAG 2828.

TEST OBSERVATIONS. The test pallet was loaded with 64 Prototype PA 120 40mm containers filled with approximately 190 pounds of iron granules, creating a total of 4,018 pounds unitized load.

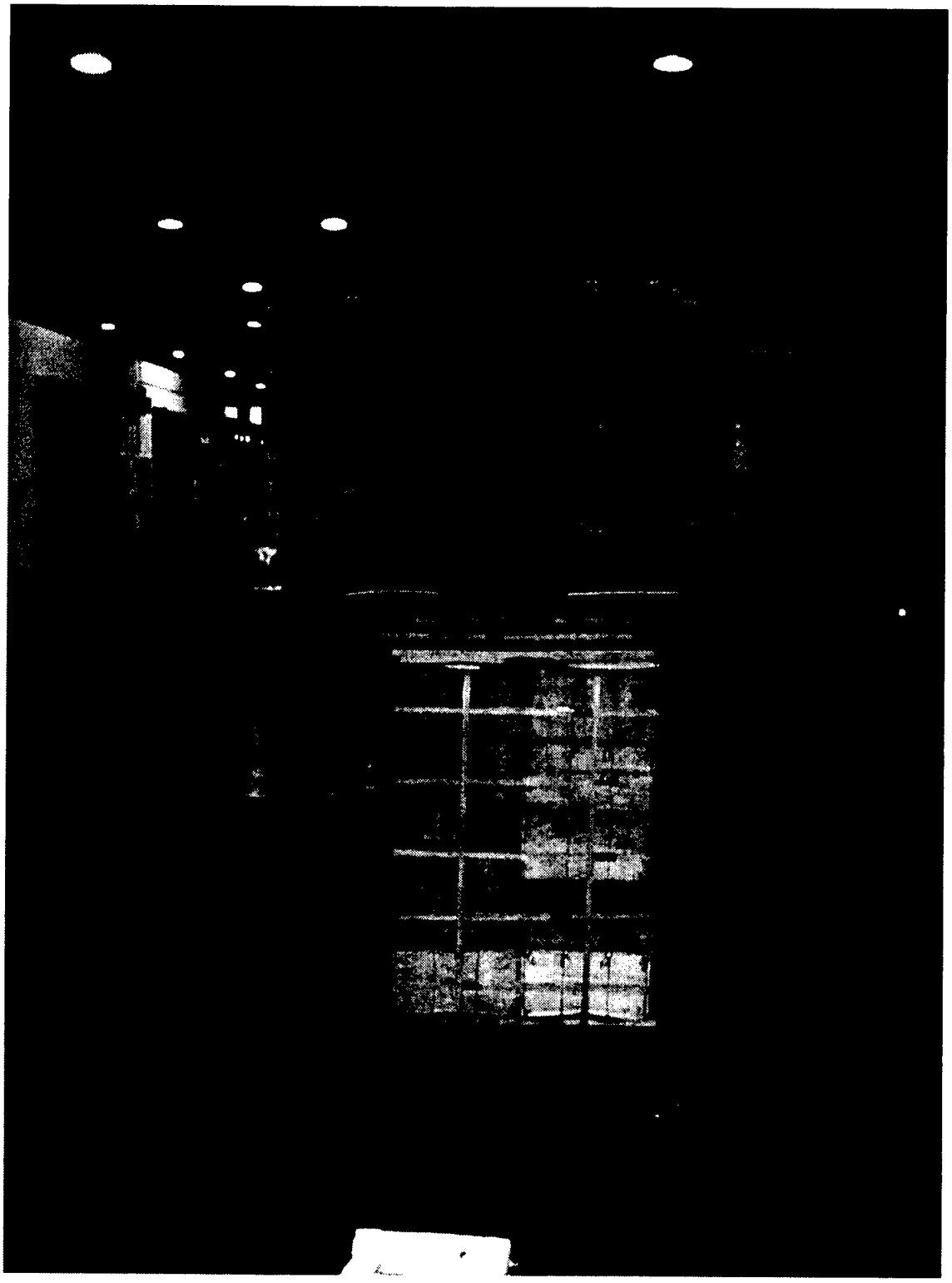
A. STACKING TEST. The test sample was initially loaded to 21,000 pounds compression. After one hour, the compression was released. No physical damage to the test sample was noticed.

B. REPETITIVE SHOCK TEST. During vibration, the nails on the outer middle post sheared and the outer bottom decks (skid) came loose. The nails were replaced and testing commenced. Half way through the cycle, two outer posts and the outer bottom deck (skid) broke off as the nails sheared. At this point, testing was terminated.

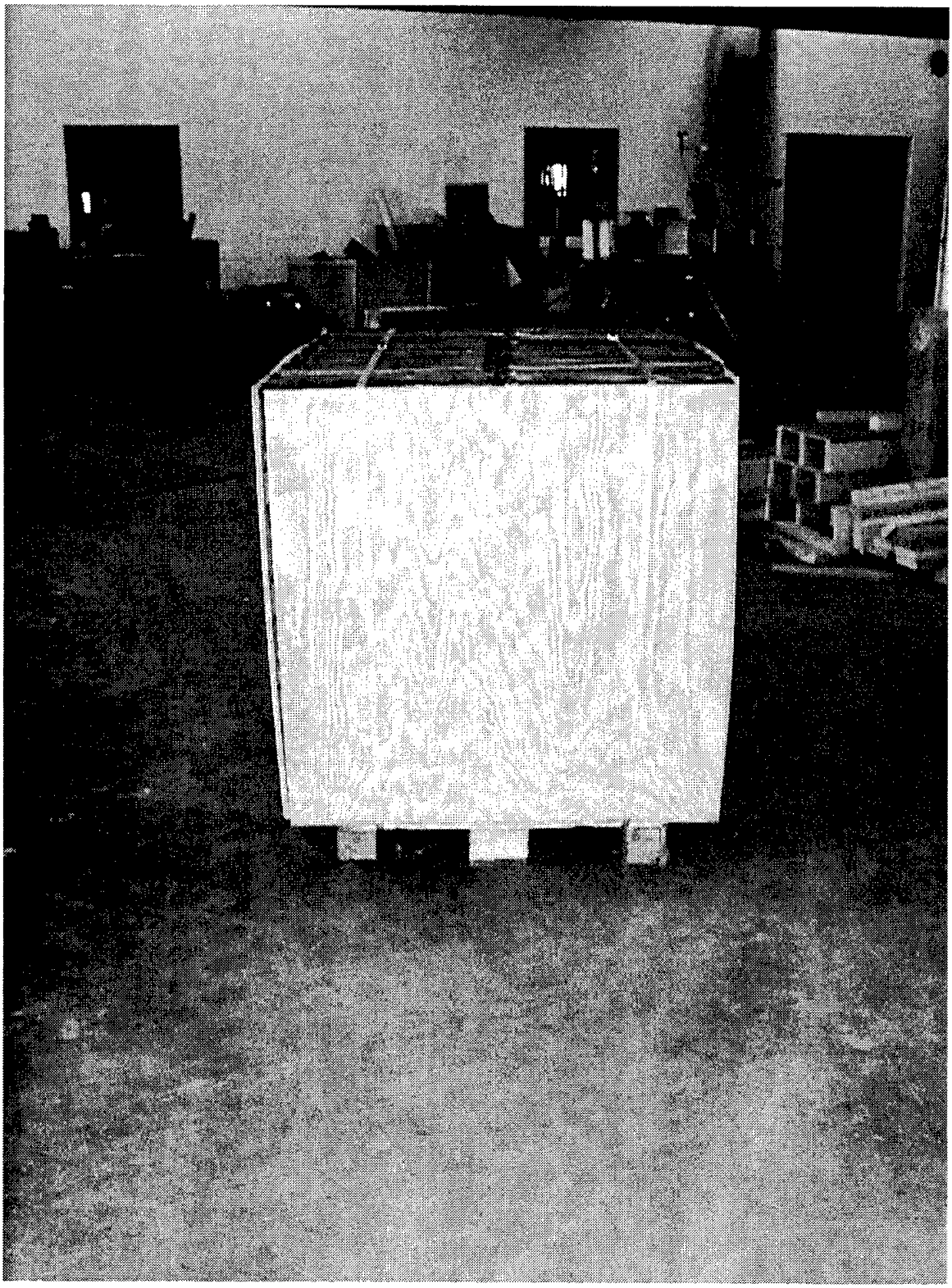
C. END OF TEST INSPECTION. During final inspection, the test sample was damaged beyond usefulness. Therefore the assembly structure did not meet MIL-STD-1660 test requirements.

PART 6

PHOTOGRAPHS



| | U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL | |
|---|---|---|
| PHOTO NO. DAC-DEV-98-06-JOE1. This photograph shows a load of 3W (6,000 pounds) used during STANAG 2828 testing. | | |



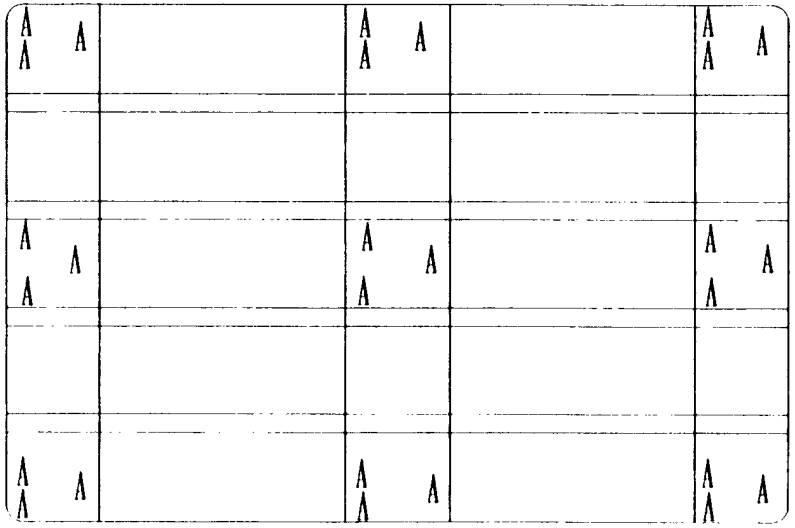
| | U.S. ARMY DEFENSE AMMUNITION CENTER AND SCHOOL - SAVANNA, IL | |
|---|---|---|
| PHOTO NO. DAC-DEV-98-06-PKG1F. This photograph shows a load of PA 120 40mm boxes used during MIL-STD-1660 testing. | | |

PART 7

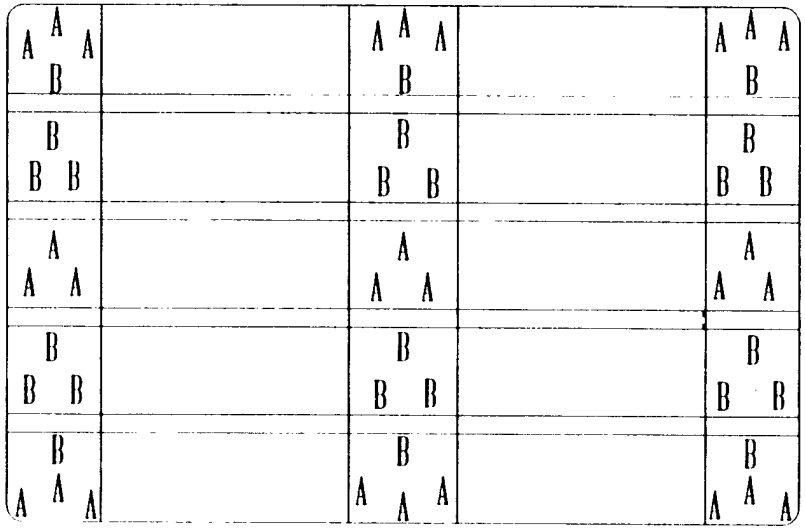
DRAWINGS

# WOODEN EUROPALLET NAILING DIAGRAM

## 32- BY 48-INCH PALLET



BOTTOM DECK BOARDS
(SKIDS)
VIEW FROM BELOW



TOP DECK BOARDS
(DECK)
PLAN

NOTES: A = 3-1/2-inch nail
B = 2-4/25 to 2-9/25-inch nail

EJA
03/31/98

# TABLE 1

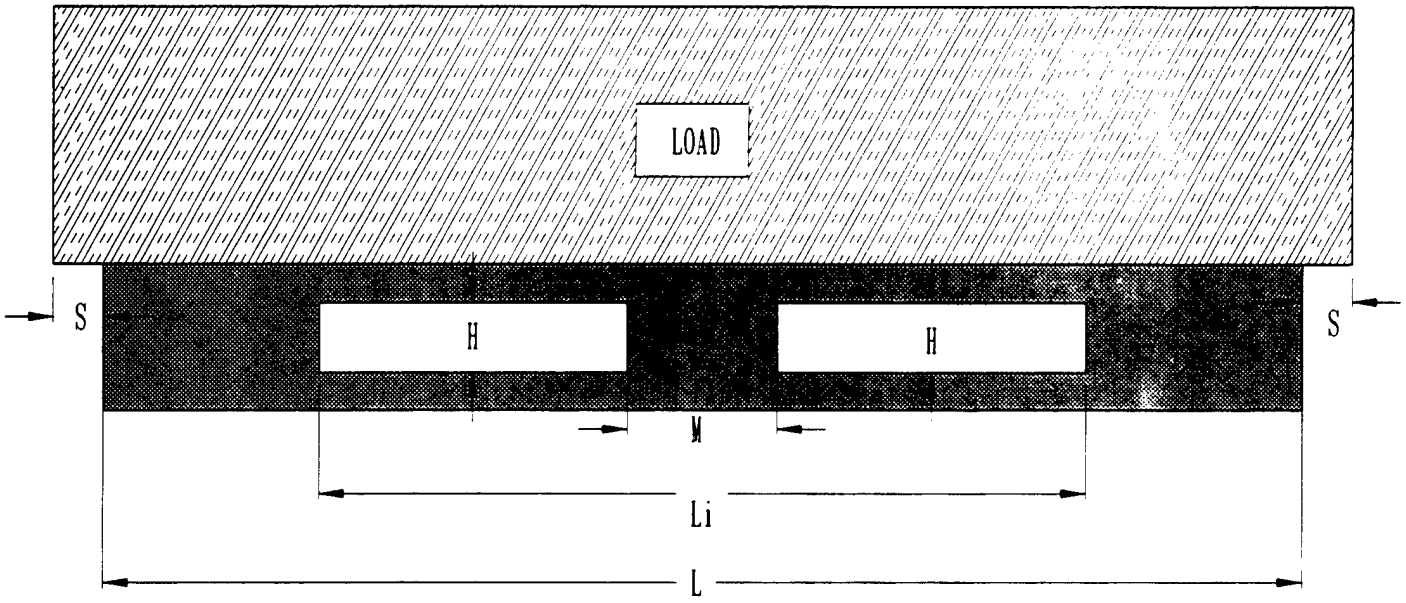
## DIMENSIONS OF NATO STANDARD FOUR-WAY PALLETS

| Serial | Description | Nominal Dimensions | | Actual Length | | Actual Width | | Height | | Pallet Capacity (Nominal) | | Load Stack Capacity (Nominal) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mm | in | mm | in | mm | in | mm | in | kg | lb | kg | lb |
| a | b | c | d | e | f | g | h | j | k | l | m | n | o |
| 1 | NATO Standard Four - way Pallets | 1200 x 800 | 48 x 32 | 1200 + 20 - 0 | 48 + 0 - 0.750 | 800 + 15 - 0 | 32 + 0 - 0.500 | | | 1000 | 2205 | 4000 | 8820 |
| 2 | | 1200 x 1000 | 48 x 40 | 1200 + 20 - 0 | 48 + 0 - 0.750 | 1000 + 16 - 0 | 40 + 0 - 0.625 | | | 1000 | 2205 | 4000 | 8820 |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

NOTE: The tolerance permitted in the above table are applied in an opposite sense for metric and inch dimensions to help to bring the two measurements into line.

## FIGURE 1

## NATO STANDARD FOUR-WAY LIMITING DIMENSIONS




NOTES: 1. The drawing does not show the method of construction of the pallet, but illustrates the dimensions which are limited in table 2.
2. The limiting dimensions applicable to the NATO standard four-way pallet are as follows:

PALLET TO PASS THROUGH

Table 2

| Side pallet dimension L (nominal) | | Width of center support, M (maximum) | | Entry Width Li (minimum) | | Entry Height H (minimum) | | Load overhang S (maximum) | |
|---|---|---|---|---|---|---|---|---|---|
| mm | in | mm | in | mm | in | mm | in | mm | in |
| 800 | 32 | 150 | 6 | 600 | 24 | 99 | 3.875 | 40 | 1.5 |
| 1000 | 40 | 150 | 6 | 710 | 28 | 99 | 3.875 | 40 | 1.5 |
| 1200 | 48 | 150 | 6 | 710 | 30.75 | 99 | 3.875 | 50 | 2 |